CLAIMS

1. A system for assisting and easing the rehabilitation of spinal cord, stroke and traumatic brain injured people (as well as others with injury affecting locomotion) to regain walking capabilities comprising

(a) an individually adjustable automated body weight suspension training system;

(b) multiple sensors wherein said sensors provide feedback to adjust the automated body weight suspension training system.

2. The system of claim 1 further comprising:

(a) two pairs of motor-driven mechanical linkage units;

(b) each of said units with two mechanical degrees-of-freedom;

(c) said units connected with their drive elements to a fixed base of a treadmill;

(d) said linkages' free ends wherein said free ends are attachable to the patient's legs at two locations at each leg; wherein one linkage pair serves one leg in the sagittal plane of bipedal locomotion; and wherein the other linkage pair serves the other leg in the sagittal plane of bipedal locomotion.

3. The system of claim 1 further comprising:

(a) an exoskeleton linkage system with its passive compliant elements wherein said exoskeleton linkage system with its passive compliant elements are adjustable to an individual patient's geometry and dynamics.

4. The system of claim 3 further comprising: said linkage system arrangement wherein said linkage system arrangement is capable of reproducing the profile of bipedal locomotion and standing in the sagittal plane, from a fixed base.

5. The system of claim 1 further comprising:

(a) a control system for a programmable stepping device;

(b) said computer based control system of a linkage system of the programmable stepping device;

(c) said control system referenced to individual stepping models, treadmill speed, and force, torque, electromyogram (EMG) and acceleration data;

(d) said data sensed at the linkages' exoskeleton contact area with each of the patient's legs.

6. The system of claim 1 further comprising:

(a) control algorithms of the exoskeleton linkages' computer control system

(b) said control algorithms being "intelligent" control for biped locomotion wherein said algorithms distinguish between the amount and direction of the force/torque generated by the patient, by the feet's contact with the treadmill, and by the action of the programmable stepping device;

(c) said control system monitoring and controlling each leg independently..

7. The system of claim 1 further comprising:

said control system operating by way of feedback through sensors for force, torque, acceleration, and pressure located at various points on or in the exoskeleton system; wherein no wires are required to go to the human body.

8. The system of claim 1 further comprising:

a keyboard attached to the treadmill wherein the user, one or more, selected from the group consisting of patient, therapist, physician and assistant can input selected kinematic and

dynamic stepping parameters to said computer-based control system.

9. The system of claim 1 further comprising:

an externally located digital monitor system wherein the patient's stepping performance is selectively displayed in real time.

10. The system of claim 1 further comprising:

a data recording system wherein the storage of all training related and time based and time coordinated data, including electromyogram (EMG) signals, for off-line diagnostic analysis is enabled.

11. The system of claim 1 further comprising:

(a) a minimized external mechanical load acting on the patient;

(b) a maximized work performed by the patient in generating effective stepping and standing during treadmill training.

12. The system of claim 1 further comprising:

(a) a stimulator for applying stimulation to selected flexor muscles and associated tendons;

(b) a stimulator for applying stimulation to selected extensor muscles and associated tendons.

13. The system of claim 12 wherein said stimulators for applying stimulation to selected flexor and extensor muscles and associated tendons are vibrating stimulators.

14. The system of claim 1 further comprising:
an active system for positioning the hips.

15. The system of claim 14 further comprising:
said active system wherein controlled dual T-bars position the hips.

16. The system of claim 14 further comprising:
said active system wherein motorized semi-elastic belts position the hips.

17. An apparatus for rehabilitation of spinal cord, stroke and traumatic brain injured people (as well as others with injury affecting locomotion) to regain walking capabilities comprising:

(a) an individually adjustable automated body weight suspension training apparatus;

(b) multiple sensors wherein said sensors provide feedback to adjust the automated body weight suspension training apparatus;

(c) two pairs of motor-driven mechanical linkage units;

(d) each of said units with two mechanical degrees-of-freedom;

(e) said units connected with their drive elements to a fixed base of a treadmill;

(f) said linkages' free ends wherein said free ends are attachable to the patient's legs at two locations at each leg; wherein one linkage pair serves one leg in the sagittal plane of bipedal locomotion; and wherein the other linkage pair serves the other leg in the sagittal plane of bipedal locomotion.

18. The apparatus of claim 17 further comprising:

(a) an exoskeleton linkage system with its passive compliant elements wherein said exoskeleton linkage system with its passive compliant elements are adjustable to an individual patient's geometry and dynamics;

(b) said linkage system arrangement wherein said linkage system arrangement is capable of reproducing the profile of bipedal locomotion and standing in the sagittal plane, from a fixed base.

19. The apparatus of claim 17 further comprising:

(a) a control system for a programmable stepping device;

(b) said computer based control system of a linkage system of the programmable stepping device;

(c) said control system referenced to individual stepping models, treadmill speed, and force, torque, electromyogram (EMG) and acceleration data;

(d) said data sensed at the linkages' exoskeleton contact area with each of the patient's legs.

20. The apparatus of claim 17 further comprising:

(a) control algorithms of the exoskeleton linkages' computer control system

(b) said control algorithms being "intelligent" control for biped locomotion wherein said algorithms distinguish between the amount and direction of the force/torque generated by the patient, by the feet's contact with the treadmill, and by the action of the programmable stepping device;

(c) said control system monitoring and controlling each leg independently..

(d) said control system operating by way of feedback through sensors for force, torque, electromyogram (EMG) , acceleration, and pressure located at various points on or in the exoskeleton system; wherein no wires are required to go to the human body.

21. The apparatus of claim 17 further comprising:

(a) a keyboard attached to the treadmill wherein the user, one or more, selected from the group consisting of patient, therapist, physician and assistant, can input selected kinematic and
dynamic stepping parameters to said computer-based control system;

(b) an externally located digital monitor system wherein the patient's stepping performance is selectively displayed in real time;

(c) a data recording system wherein the storage of all training related and time based and time coordinated data, including electromyogram (EMG) signals, for off-line diagnostic analysis is enabled.

22. The apparatus of claim 17 further comprising:

(a) a minimized external mechanical load acting on the patient;

(b) a maximized work performed by the patient in generating effective stepping and standing during treadmill training.

23. The system of claim 17 further comprising:

(a) a stimulator for applying stimulation to selected flexor and associated tendons;

(b) a stimulator for applying stimulation to selected extensor muscles and associated tendons.

24. The system of claim 23 wherein said stimulators for applying stimulation to selected flexor and extensor muscles are vibrating stimulators.

25. The apparatus of claim 17 further comprising:
an active system for positioning the hips.

26. The apparatus of claim 25 further comprising:
said active system wherein controlled dual T-bars position the hips.

27. The apparatus of claim 25 further comprising:
said active system wherein motorized semi-elastic belts position the hips.

28. A method for assisting and easing the rehabilitation of spinal cord, stroke and traumatic brain injured people (as well as others with injury affecting locomotion) to regain walking capabilities comprising the steps of:

(a) providing an individually adjustable automated body weight suspension training system;

(b) operating multiple sensors wherein said sensors provide feedback to adjust the automated body weight suspension training system.

29. The method of claim 28 further comprising the steps of:

(a) utilizing two pairs of motor-driven mechanical linkage units;

(b) having each of said units with two mechanical degrees-of-freedom;

(c) connecting said units with their drive elements to a fixed base of a treadmill;

(d) attaching said linkages' free ends the patient's legs at two locations at each leg;

(e) serving one leg in the sagittal plane of bipedal locomotion with a first linkage pair;

(f) serving the other leg in the sagittal plane of bipedal locomotion with a second linkage..

30. The method of claim 28 further comprising the step of:

(a) adjusting an exoskeleton linkage system with its passive compliant elements to an individual patient's geometry and dynamics.

31. The method of claim 28 further comprising the step of

(a) arranging said linkage system;

(b) reproducing the profile of bipedal locomotion;

(c) standing in the sagittal plane, from a fixed base.

32. The method of claim 28 further comprising the steps of:

(a) controlling, with a computer-based control system, a programmable stepping device;

(b) controlling, with a computer-based control system, a linkage system of the programmable stepping device;

(c) referencing said control system to individual stepping models, treadmill speed, and force, torque, electromyogram (EMG) and acceleration data;

(d) sensing said data at the linkages' exoskeleton contact area with each of the patient's legs.

33. The method of claim 28 further comprising the steps of:

(a) control algorithms of the exoskeleton linkages' computer control system

(b) utilizing control algorithms for "intelligent" control for biped locomotion wherein said algorithms distinguish between the amount and direction of the force/torque generated by the patient, by the feet's contact with the treadmill, and by the action of the programmable stepping device;

(c) monitoring and controlling each leg independently..

34. The method of claim 28 further comprising the steps of:

(a) operating said control system by way of feedback through sensors for force,torque, acceleration, and pressure located at various points on or in the exoskeleton system;

(b) requiring no wires to attach to the human body.

35. The method of claim 28 further comprising the step of:

attaching a keyboard to the treadmill wherein the user, one or more, selected from the group consisting of patient, therapist, physician and assistant can input selected kinematic and
dynamic stepping parameters to said computer-based control system.

36. The method of claim 28 further comprising the step of:

utilizing an external digital monitor system wherein the patient's stepping performance is selectively displayed in real time.

37. The method of claim 28 further comprising the step of:

utilizing a data recording system wherein the storage of all training related and time based and time coordinated data, including electromyogram (EMG) signals, for off-line diagnostic analysis is enabled.

38. The method of claim 28 further comprising the steps of:

(a) minimizing an external mechanical load acting on the patient;

(b) maximizing work performed by the patient in generating effective stepping and standing during treadmill training.

39. The method of claim 28 further comprising the steps of:

(a) applying stimulation to selected flexormuscles and associated tendons;

(b) applying stimulation to selected extensormuscles and associated tendons.

40. The system of claim 39 further comprising the step of vibrating said selected flexor and extensormuscles and associated tendons for said stimulation.

41. The method of claim 28 further comprising the step of :

positioning, actively, the hips..

42. The method of claim 28 further comprising the step of:

controlling, actively, the hips with dual T-bars.

43. The method of claim 28 further comprising the step of:

controlling, actively, the hips with motorized semi-elastic belts.

44. A method of using a system for assisting and easing the rehabilitation of spinal cord, stroke and traumatic brain injured people (as well as others with injury affecting locomotion) to regain walking capabilities comprising the steps of:

(a) fitting the patient into the attachment units for the patient's legs and adjusting the system for the patient's upper and lower leg lengths, body weight, height, and other parameters of fitting;

(b) fitting and adjusting the patient's hip restraints;

(c) fitting the stimulating units to the surface of desired flexor and extensor muscle group areas;

(d) turning on the system and allowing it to move the patient's legs with any appropriate additional motion required for patient's hip s or upper body;

(e) applying stimulation to the desired flexor and extensor muscle group areas at appropriate sequential times;

(f) turning off the system and releasing patient from fittings and manually assisting patient from a treadmill.

45. The method of using of claim 44 further comprising the step of: stimulating selected flexor and extensor muscles and associated tendons.

46. The method of using of claim 45 further comprising the step of:

applying vibration to stimulate said selected flexor and extensor muscles and associated tendons.

47. The method of using of claim 45 further comprising the step of :

positioning, actively, the hips.

48. The method of using of claim 45 further comprising the step of:

controlling, actively, the hips with dual T-bars.

49. The method of using of claim 45 further comprising the step of:

controlling, actively, the hips with motorized semi-elastic belts.